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(54) Trench cutter.

(57) The milling cutters (3, 4) are suspended on pivot arms (15, 16). Those pivot arms (15, 16) are pivotably mounted to an intermediate support structure (18). The pivot axes (24) of the pivot arms (15, 16) extend perpendicularly to the axes of rotation (3, 4) of the milling cutters (3, 4). These pivot arms (15, 16) are operated by hydraulic actuators (20). Therefore, in operation the milling cutters (3, 4) will oscillate over the bottom of a trench (11) being excavated such that no center ridge remains at the bottom of the trench which would call for additional operational procedures in order to be removed. Furthermore, the intake (35) of the suction pipe (34) for the removing of the milled off matter by means of a slurry being circulated is located close to the zone where the milling takes place. Therefore, the efficiency of the circulated volume of the slurry regarding the volume of milled material taken along is much improved. Because the milling cutters (3, 4) can pivot, their thickness can be smaller in spite of covering the complete width of the trench being excavated. Accordingly, they can act with a much higher pressure per surface unit onto the ground, thus enabling the use of rock bits such that also hard rock can be milled.

Fig. 3

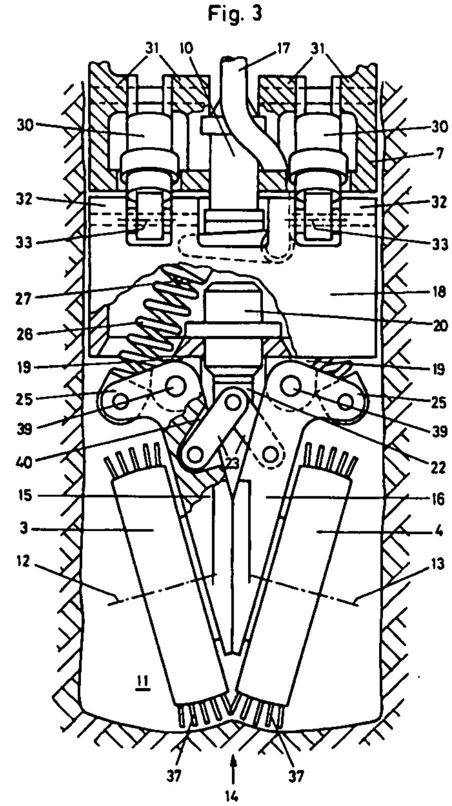
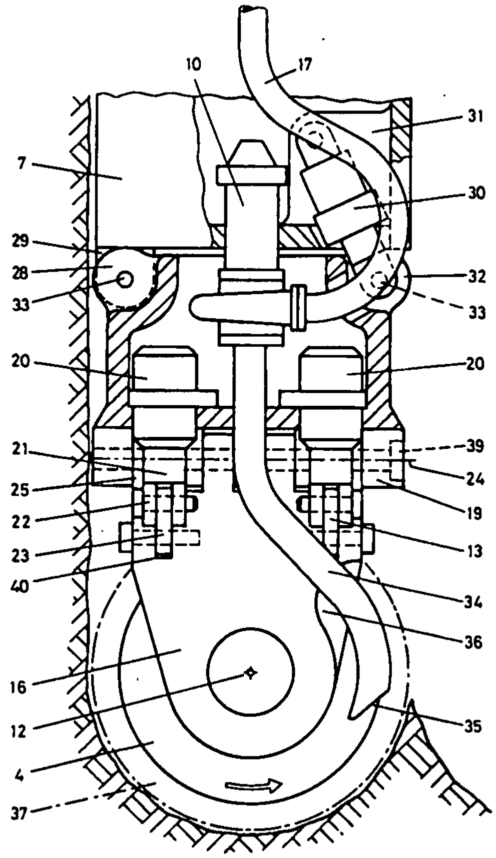


Fig. 4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The present invention relates to a trench cutter having a milling head and a supporting frame, which milling head is mounted to the support frame and includes at least one rotatable milling cutter.

Such trench cutters are used e.g. for excavation work where long and deep slots are excavated in the ground and filled thereafter. Such slots are excavated at construction procedures known as diaphragm wall technique and as slurry trench technique.

The critical components of these trench cutters are the milling heads with the milling cutters. The generally known milling heads have, however, a number of drawbacks. The milling heads include generally two milling cutters mounted side-by-side on a common axis. This axis extends perpendicularly to a supporting plate at which the milling cutters are suspended, which supporting plate extends vertically between the two drum shaped milling cutters. Due to this plate an area exists at the bottom of the trench being excavated in the ground which cannot be reached by the milling cutters or their tools, respectively, leaving an elongated ridge at the bottom of the trench. When the ground is of a soft material, this ridge may be crushed by the supporting plate. But in rock, however, a destroying of this ridge poses more or less difficult problems which even may be unsurmountable. Several attempts have been made to design milling cutters such that they are in a position to also remove this ridge e.g. by pivotable milling tools such as e.g. disclosed in the US-PS 4,824,176, 4,718,731, 4,800,967. These pivotable milling tools are, however, not sturdy enough to cope with large shearing stresses when working in a harder ground and, specifically, cannot be used when excavating in a hard rock ground.

Further, the material which has been loosened by the milling cutters is transported off together with the scavenging slurry by means of e.g. an air lift or a pumping device. Since the milling heads and the center supporting plate of the known designs occupy the entire front face area of the milling head, the intake of the mouth piece of the pipe for removing the material and the slurry must be located someplace above the milling cutters and, therefore, a considerable distance away from the area where the actual working of the soil occurs. Accordingly, the milled off material must be moved past the drum-shaped milling cutters, a procedure which not only consumes energy but also adds to the abrasion of the milling tools. Furthermore, a large volume part of the scavenging slurry moves from zones above the milling cutters directly into the intake of the suction pipe located at a somewhat elevated level relative to the bottom of the trench and, therefore, mentioned volume part does not take part in the transporting off of the milled matter. As a matter of fact, the slurry being pumped off includes about only 3% milled off material which obviously means that enormous amounts of scavenging slurry must be circulated and that the advancing of the milling is rather small.

The invention as claimed is intended to provide a remedy. It solves the problem of how to design a trench cutter in which the area to be worked is completely swept by the milling cutters, in that the milling cutters are supported to pivot relative to the supporting frame thereof.

The advantages offered by the invention are mainly that the complete surface area of the soil to be removed is acted upon by the milling cutter tools, further that the intake of the suction pipe is located in a zone where the slurry transporting the milled off matter flows and not at a location where the freshly fed slurry which has not come into contact with the milled off matter is present.

A way of carrying out the invention is described in detail below with reference to drawings which illustrate an embodiment, in which

Fig. 1 is a general view of a trench cutter embodying the present invention,

Fig. 2 is a view, partly in section, of a milling head with the pivotable milling cutters in a first position, whereby the suction tube is illustrated only in part,

Fig. 3 is a view similar to the view of Fig. 2 with the milling cutters in a second position, and without the suction tube,

Fig. 4 is a view of a section along line IV-IV of Fig. 3,

Fig. 5 is a view similar to the view of Fig. 2 of the milling head, and

Figs. 6 and 7 are illustrations in an exploded view of parts of a cutter head.

The trench cutter illustrated in Fig. 1 comprises a milling head 1 which includes in this specific example two pairs of counterrotating milling cutters 3, 4 and 5, 6 arranged in a tandem-like sequence. It shall be noted, however, that this arrangement is exemplary only and other arrangements, e.g. only one pair of milling cutters, are foreseen, too.

The milling head 1 is mounted to a support frame 7 suspended from the jib 8 of a construction machine 9.

Reference numeral 10 denotes in this specific example the pump for the removal of the scavenging slurry and milled off material which is fed through a conduit 17 for removal at a corresponding site. As is well known, other devices such as an air lift device can be utilized in place of the pump 10. Finally, the trench being excavated by the trench cutter is identified by the reference numeral 11.

Attention is drawn now to Fig. 2 illustrating a

front view of the milling head with parts partly cut away, and, for a better understanding, also to Fig. 7 of the drawings. Fig. 2 specifically shows the milling head in an operational position in a trench 11.

The two rotating milling cutters 3, 4, which will be described more in detail further below, rotate around their axes of rotation 12, 13.

As can be seen, the center area 14 of the trench 11 is not worked by the two milling cutters 3, 4 when they are in the illustrated position, which position, by the way, is typical for the designs of the prior art.

Both milling cutters 3, 4 are now mounted to a pivot arm, i.e. milling cutter 3 to the pivot arm 15 and milling cutter 4 to the pivot arm 16. These pivot arms 15, 16 are generally platelike structures such as e.g. designed in Fig. 6. Since the designs regarding the left and the right hand side of Fig. 2 are the same, the here following description is confined to the left half of Fig. 2.

Pivot arm 15 is pivotably mounted to a framelike intermediate support structure 18. To this end, the pivot arm 15 has upwards projecting lugs 38 and the intermediate support structure downwards projecting lugs 19, and the interconnection therebetween is made by a horizontally extending bolt 39. This intermediate support structure 18 carries an actuator e.g. in form of a hydraulic piston/cylinder device 20. The lower end of its piston rod 21 is provided with a lug 22. A linkage arm 23 is hinged at the one end to the lug 22 and at the other end to the pivot arm 15, which has a recess 40 for receipt of the linkage arm 23.

When viewing Figs. 4 and 6, it can be seen that two such hydraulic piston / cylinder devices 20 are installed. Accordingly, by actuating the actuator 20, the pivot arm 15 (and obviously simultaneously pivot arm 16) will pivot around a pivot axis 24, which extends perpendicularly to the axis of rotation 12 of the milling cutter 3 (and 4).

At a nose shaped end 25 remote from the pivot axis 24 the pivot arm 15 is connected to a spring 26 which rests against a projection 27 of the intermediate support structure 18. The purpose of this spring 26 is to dampen the oscillating movements of the pivot arm 15.

In operation, the two milling cutters 3, 4 can sweep and work accordingly the entire bottom area of the trench 11 in that they oscillate between the position illustrated in Fig. 2 and the position illustrated in Fig. 3 such that no elongated center ridge remains at the bottom of the trench 11 and also that rocks and rubble located in this center area are also worked and milled by the milling cutters.

The intermediate support structure 18 can be an integral part of the support frame 7 or, as disclosed in this embodiment can be in turn pivotably mounted to the support frame 7.

This arrangement will now be described based mainly on Figs. 2 and 6.

The intermediate support structure 18 includes along one of its upper edges lugs 28, via which it is hinged to complementary lugs 29 of the support frame 7.

Actuators 30, again e.g. hydraulic piston/cylinder devices, are hinged at the one end to webs 31 (Fig. 7) of the support structure 7 and at the other end to lugs 32 (Fig. 6) of the intermediate support structure 18. Accordingly, the intermediate support structure 18 can pivot around a pivot axis 33 extending perpendicularly to the pivot axis 24 of the pivot arm 14 and 15.

With regard to the milling cutters 3, 4 this means that they can also pivot forward upwards seen in the direction of advance of the milling operation such that not only the bottom of the trench 11 but additionally at least a part of the vertical face surface of the trench 11 can be completely swept by the two milling cutters 3, 4.

The removing of the scavenging slurry and of the milled off material is made in this illustrated embodiment by a pump 10, of which the outlet is connected to the discharge conduit 17. Attention is now drawn to Figs. 4 and 5.

The pump 10 is supported on the intermediate support structure 18. Its outlet is connected to the discharge conduit 17 leading to the site where the slurry and the excavated material are treated in accordance with any technique commonly known in this art.

The inlet of the pump 10 is connected to a suction tube 34. This suction tube 34 extends curvilinearly ending at the intake end 35 which is located lower than the axes of rotation 12, 13 of the milling cutters 3, 4. As is obvious, this tube 34 and the intake end are located in a space area within the envelope defined by the circumference of the milling cutters and not outside or above, respectively, thereof. This feature and specifically the location of the intake end 35 is possible due to the novel design of the suspension of the milling cutters, namely by the two pivot arms 15, 16, between which there now is a space for accommodating the suction tube 34. As can be seen from Fig. 4 and also Fig. 6 the pivot arms 15, 16 have a recess or cut-out 36, respectively, such that they do not interfere with the tube 34 in their closed position e.g. according to Fig. 5. Because this intake end 35 of the suction tube 34 is at a low location below the axes of rotation of the milling cutters, they and specifically their tools are in operation along a much smaller section of the circumference of the milling cutters immersed in the scavenging slurry and in the milled off material such that their wear is considerably decreased and accordingly also less power is necessary for their operation. Also, in a

given volume of scavenging slurry a much higher percentage of milled off matter than hitherto possible will be dragged along such that for a given operation a smaller amount of scavening slurry must be circulated.

The above description has been based generally on a possible embodiment, according to which one milling cutter pair 3, 4 in a side-by-side arrangement is mounted in the milling head 1.

There are, however, embodiments foreseen, which in many cases may be preferred, where the milling head 1 includes two contra-rotating milling cutter pairs 3, 4 and 5, 6 such as illustrated in Fig. 1 and also indicated in Fig. 4, which are arranged in a tandem-like sequence. In case of the two pairs of milling cutters mounted in a tandem-like arrangement the pivoting initiated by the actuators 30 is such that the milling cutter pairs, seen in the longitudinal direction of the trench, can move somewhat away from each other and thereafter again towards each other; in other words, the milling cutter pairs can be controlled to spread in the longitudinal direction of the trench being excavated.

The milling cutters 3, 4 and 5, 6 are of a design incorporating a motor having a fixed rotor and a rotating stator, a design which is generally known in this technical field. The motors can be of any known design, may such be electric, hydraulic or any other kind. They may be of low speed or equipped with mechanical reducers such that they can be designed with a stationary housing and a rotating hub instead of a fixed hub and a rotating housing. It can be a variable speed motor or connected to a variable speed reducing unit. The working tools 37 of the milling cutters can be rock bits or kennemetal picks or teeth, or other tools, depending from the quality of the soil to be worked. The consequence of this latter feature is that also hard rock can be milled without difficulties and can be reduced in size such that the milled matter can be taken up through the intake 35 and forwarded throug the pump 10. A further consequence is as follows. The rock bits chip or mill, respectively, the rock by virtue of the pressure with which their cutting edges or tips are pressed against the rock surface. It is now a generally known fact that the weight of the entire machine cannot exceed certain limits. The inventive design allows milling cutters which are of a rather small width compared with the width of the trench. Due to the small width the milling cutters can be brought to act with a higher pressure per surface unit onto the ground surface to be milled, thus enabling the use of rock bits, but at the same time due to the pivoting movement of the milling cutters the width of the trench being excavated can be kept as broad as hitherto possible with the previously known milling head designs.

Claims

1. A trench cutter having a milling head and a support frame, which milling head is mounted to the support frame and includes at least one rotatable milling cutter, characterized in that the at least one rotatable milling cutter is pivotable relative to the support frame around a pivot axis which extends perpendicularly to its axis of rotation.

2. The trench cutter of claim 1, characterized in that the at least one rotatable milling cutter is additionally pivotable relative to the support frame around a further pivot axis which extends perpendicularly to the first named pivot axis and in a plane which comprises the axis of rotation of the at least one milling cutter.

3. The trench cutter of claim 1 or 2, characterized in that the milling head comprises at least one pair of milling cutters arranged in a side-by-side relationship, which milling cutters are oscillatingly pivotable against and away from each other around pivot axes which extend perpendicularly to their axes of rotation.

4. The trench cutter of one of the preceding claims, characterized in that the milling head comprises at least one pair of milling cutters arranged at a side-by-side relationship, which both milling cutters are simultaneously pivotable relative to the support frame around the further pivot axis which extends perpendicularly to the first named pivot axis and in a plane which comprises the axes of rotation of the two milling cutters of the milling cutter pair.

5. The trench cutter of claim 3 or 4, characterized in that the two milling cutters of the respective milling cutter pair are pivotable around a pivot axis which extends perpendicularly relative to their axes of rotation between two end positions such that in operation the distance between the respective lowermost point of their circumference is the largest in the first and the smallest in the second end position of their pivoting movement, and in that the axes of the two milling cutters are at least approximately in alignment in said first end position.

6. The trench cutter of one of the preceding claims, characterized in that each respective milling cutter is supported at a pivot arm which at its end remote from the respective milling cutter is pivotably mounted to an intermediate support structure which in turn supports at least one piston-cylinder apparatus which is

coupled via a linkage to each respective pivot arm such to produce the pivoting of each respective milling cutter around the pivot axis extending perpendicularly to its axis of rotation.

7. The trench cutter of claim 6, characterized in that each pivot arm is mounted at an area remote from the pivot axis to the end of a spring, of which the opposite end is supported at the intermediate support structure.

8. The trench cutter of claim 6 or 7, characterized in that the intermediate support structure is pivotably mounted to the support frame such to be pivotable relative to the support frame around a further pivot axis which extends perpendicularly to the first named pivot axis and in a plane which comprises the axes of rotation of the milling cutters.

9. The milling cutter of claim 8, characterized in that the intermediate support structure is coupled at the end remote from the further pivot axis via at least one piston-cylinder apparatus to the support frame such to induce the pivoting movement of the intermediate support structure.

10. The trench cutter of one of the preceding claims, characterized in that the milling head comprises two contrarotating milling cutter pairs arranged in a tandem-like sequence, whereby the sense of rotation of the milling cutters is such that during the milling operation the sections of their circumferences which face each other move upwards.

11. The trench cutter of one of the preceding claims and having a means for removing the scavenging slurry together with the milled off matter and including at least one suction pipe having an intake end, characterized in that at least a part of the suction pipe extends within a space inside of the envelope plane defined by the circumference of the milling cutters such that the intake end of the suction pipe is located not higher than to a location corresponding to the height level of the axes of rotation of the respective milling cutters in their operational state or lower than mentioned height level and at a distance from the axes of rotation.

12. The trench cutter of claim 10, characterized in that the intake end of the suction pipe is located relative to the circumference of the milling cutters such that in operation thereof it is located adjacent the rising circumference sections of the milling cutters.

13. The trench cutter of claim 1, characterized in that the cutting members of each milling cutter include rock-bits which are arranged on the rotating casing of an electric motor having a fixed shaft.

Fig. 1

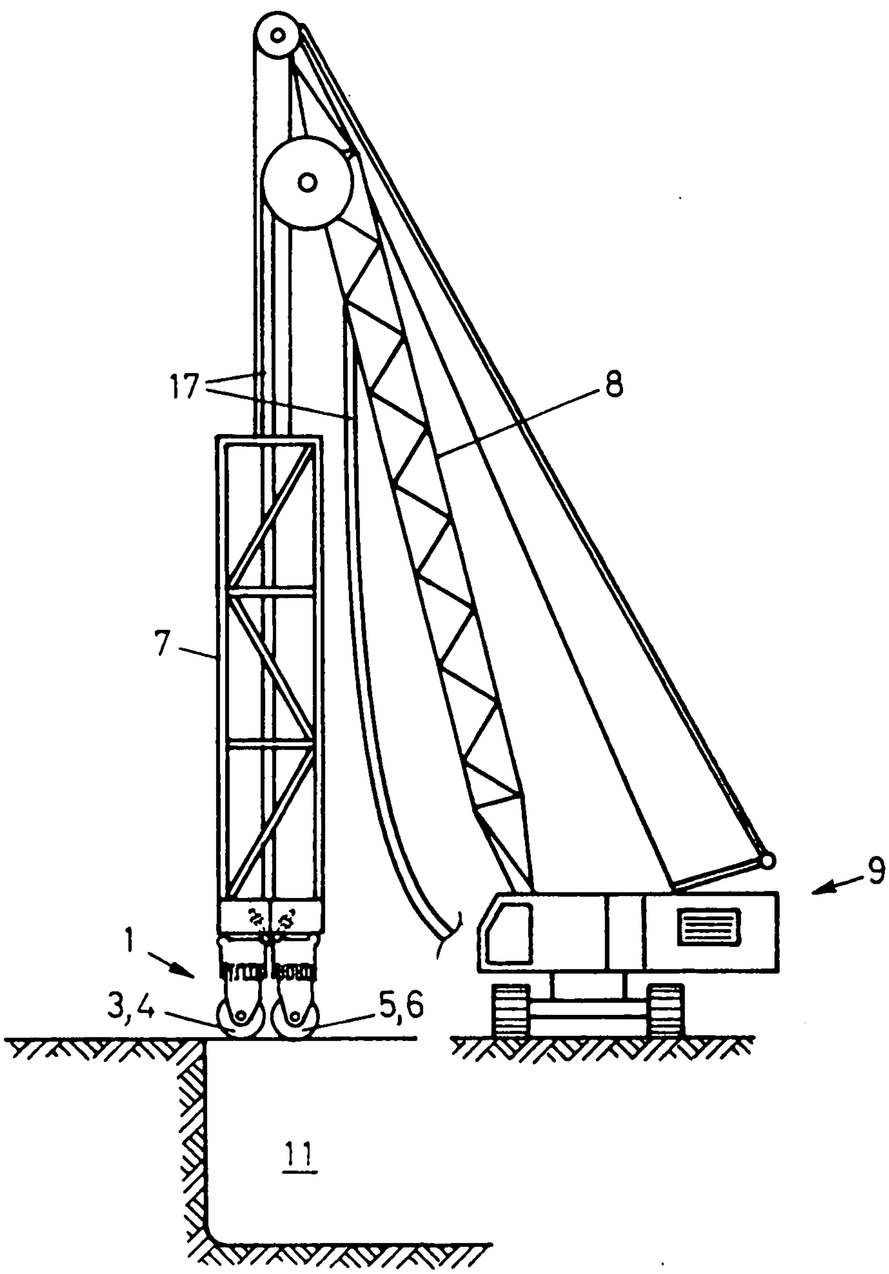

Fig. 2

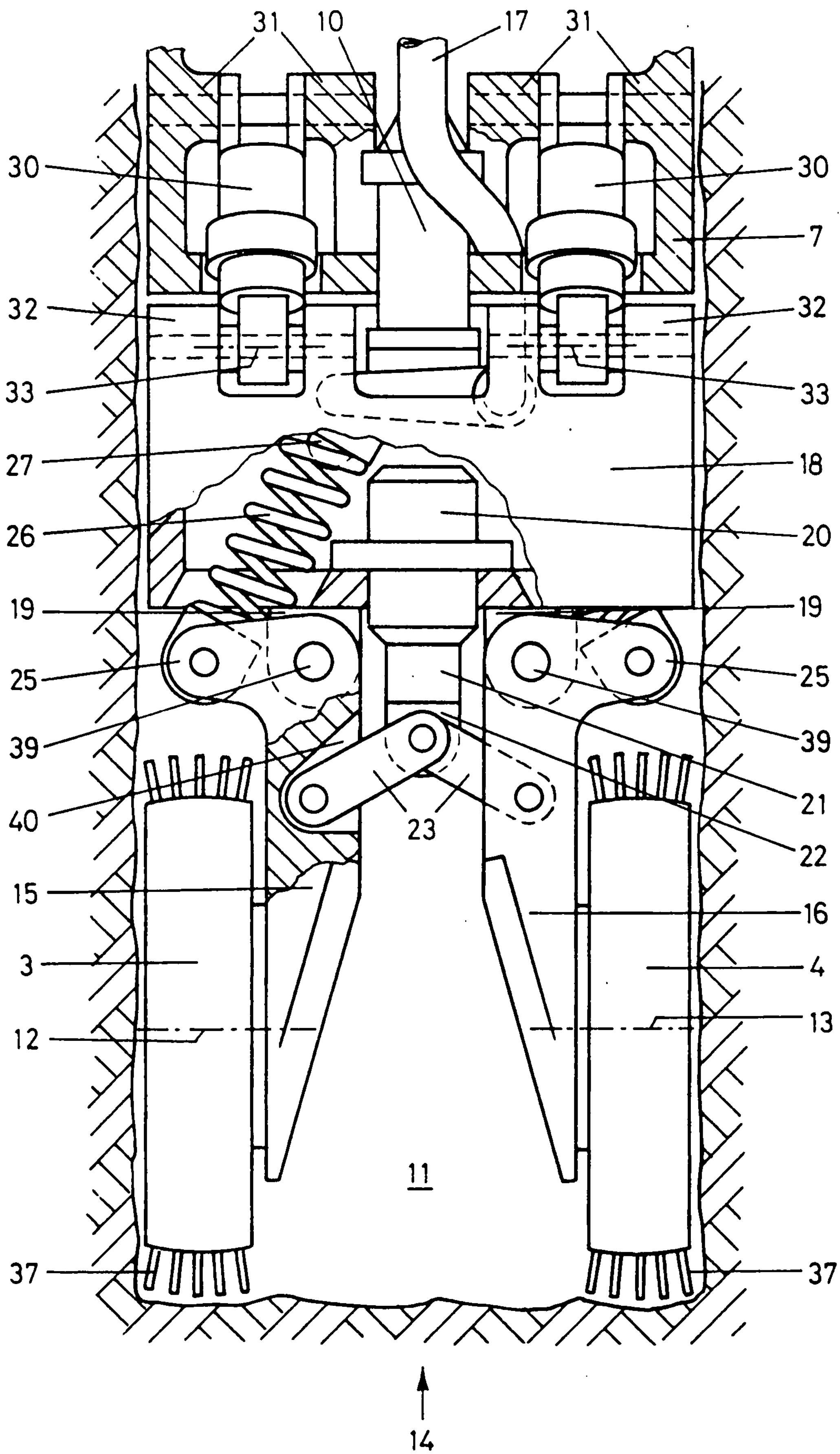
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Fig. 3

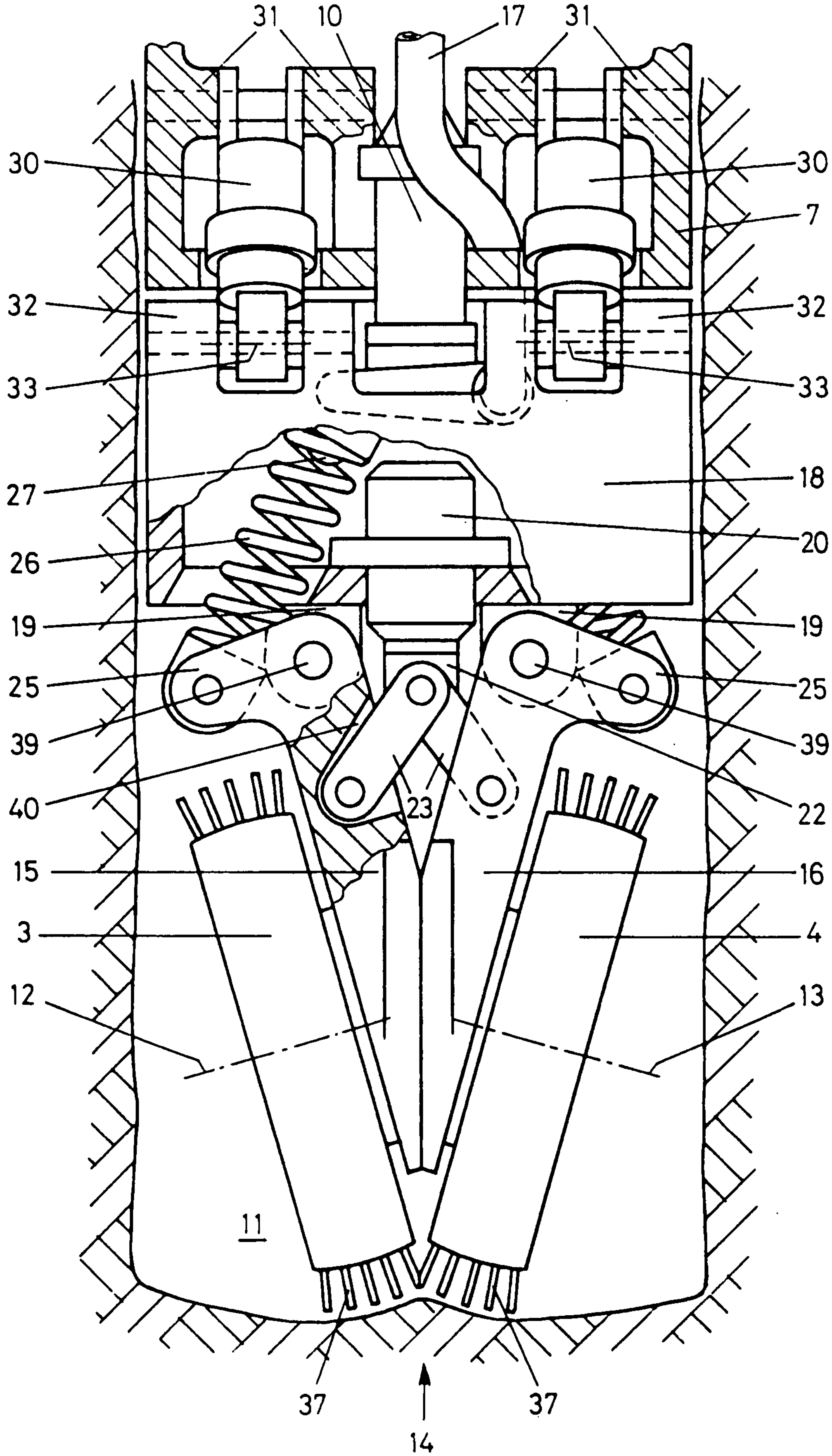
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Fig. 4

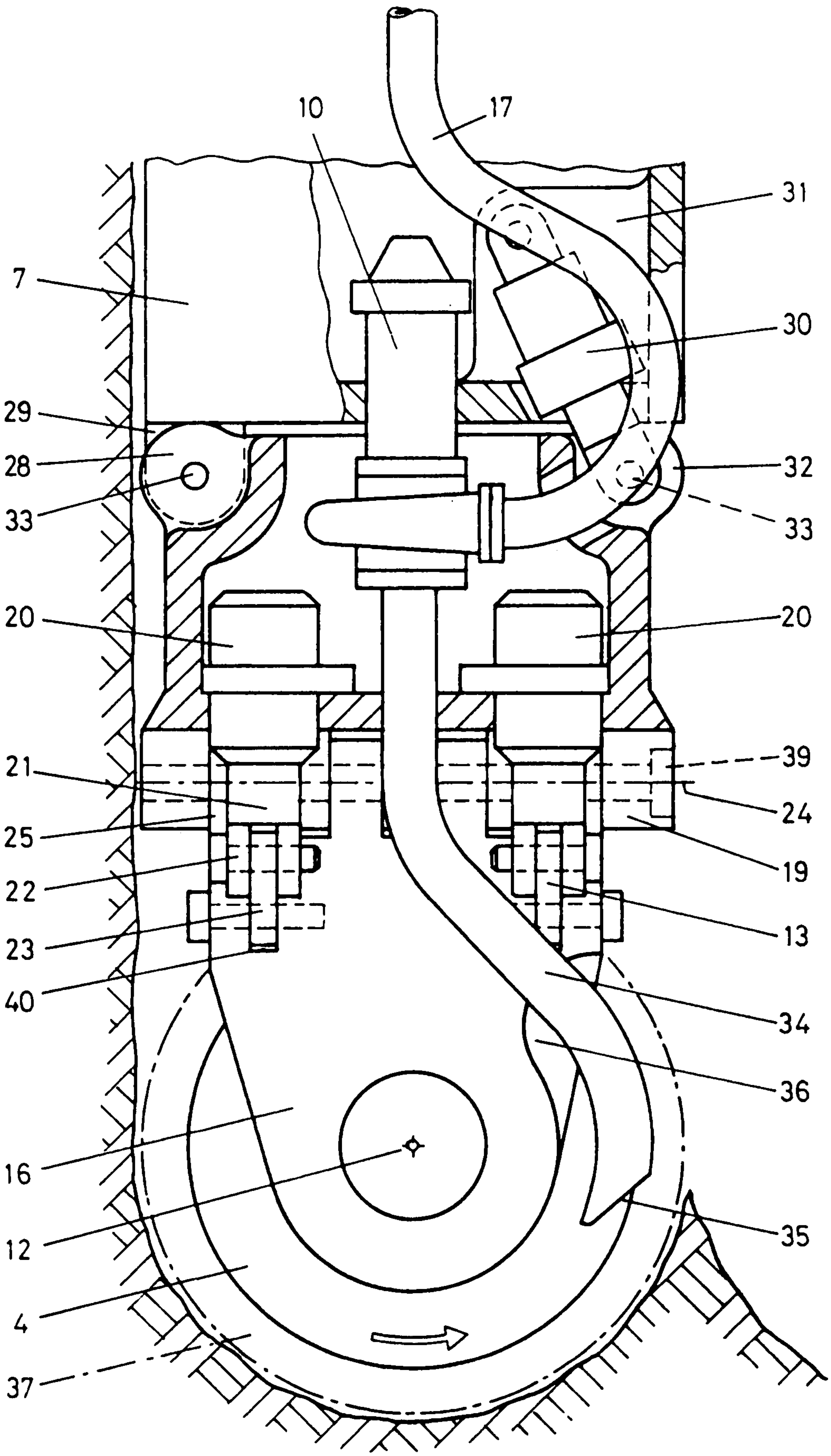
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Fig. 5

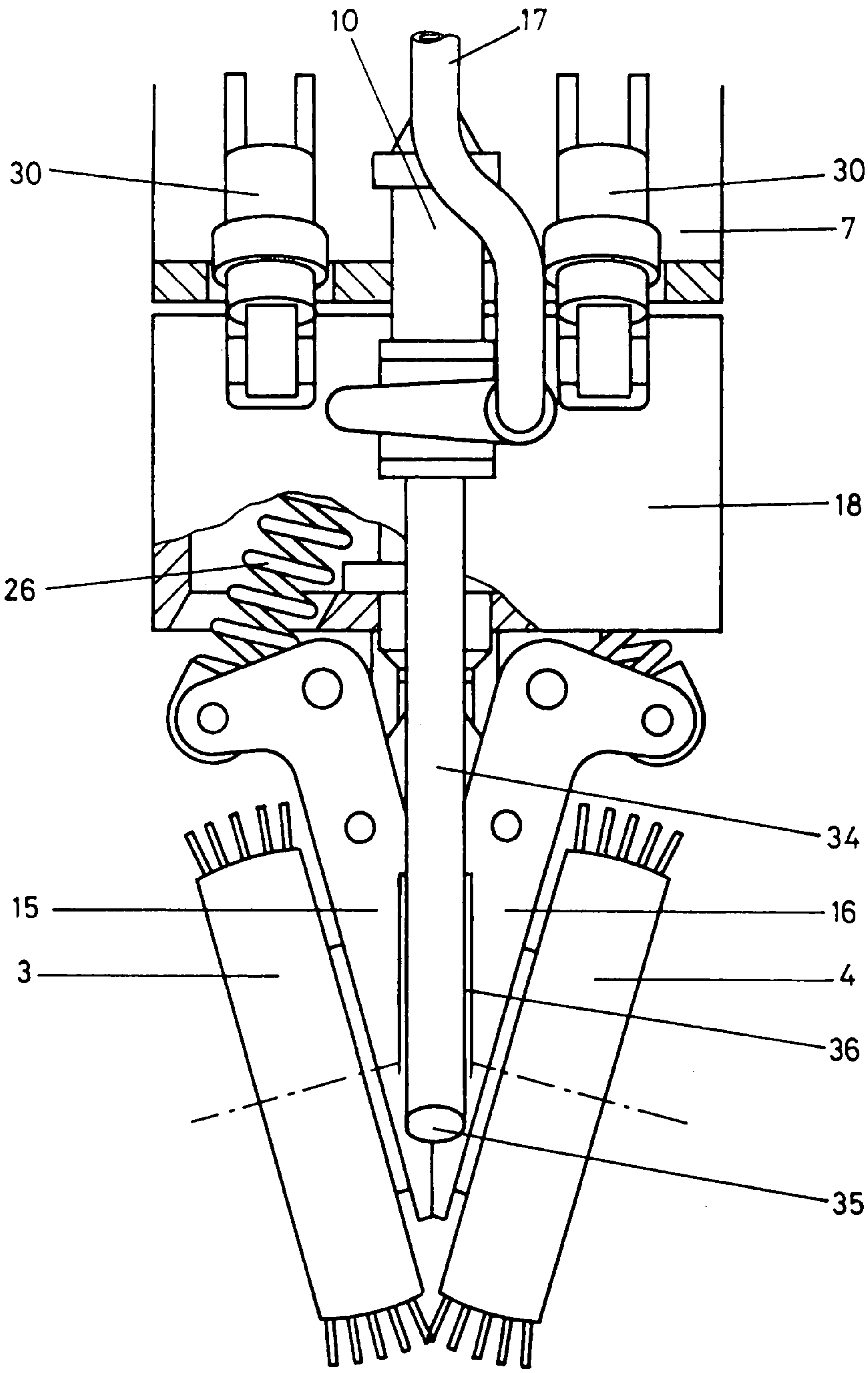

Fig.6

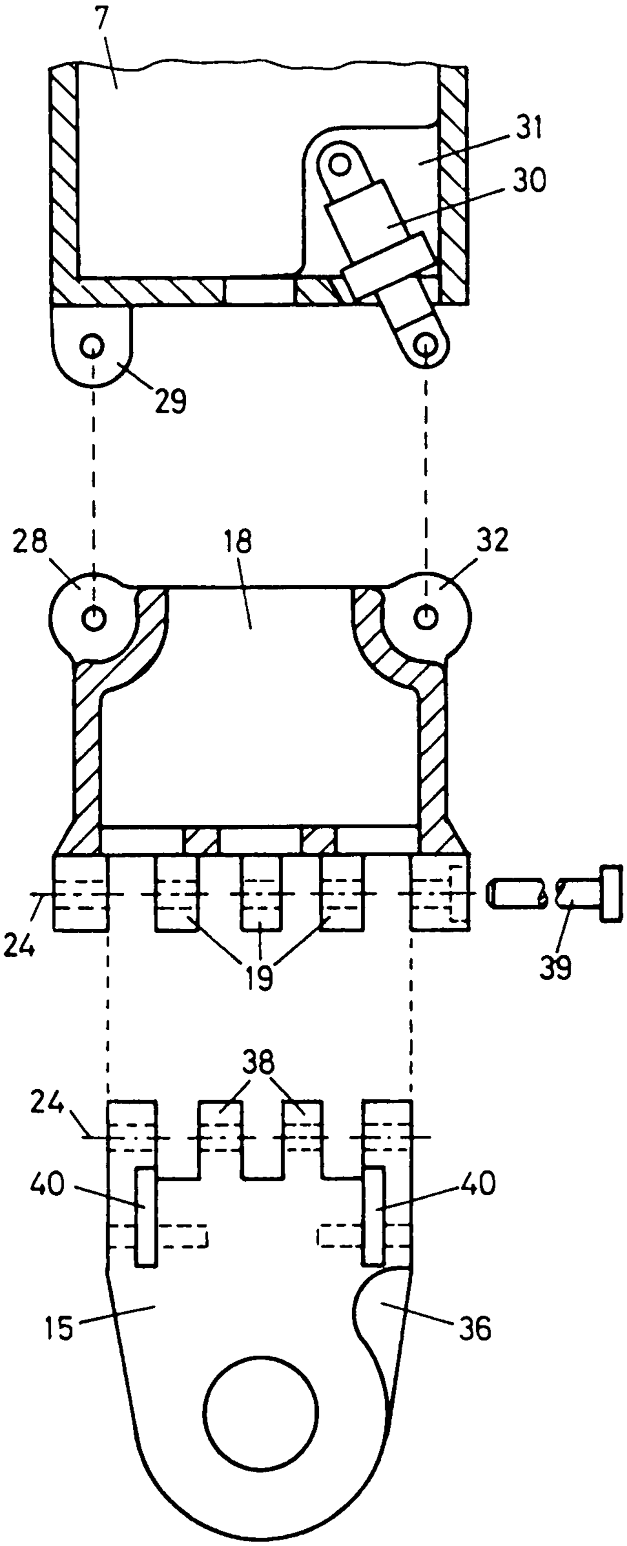
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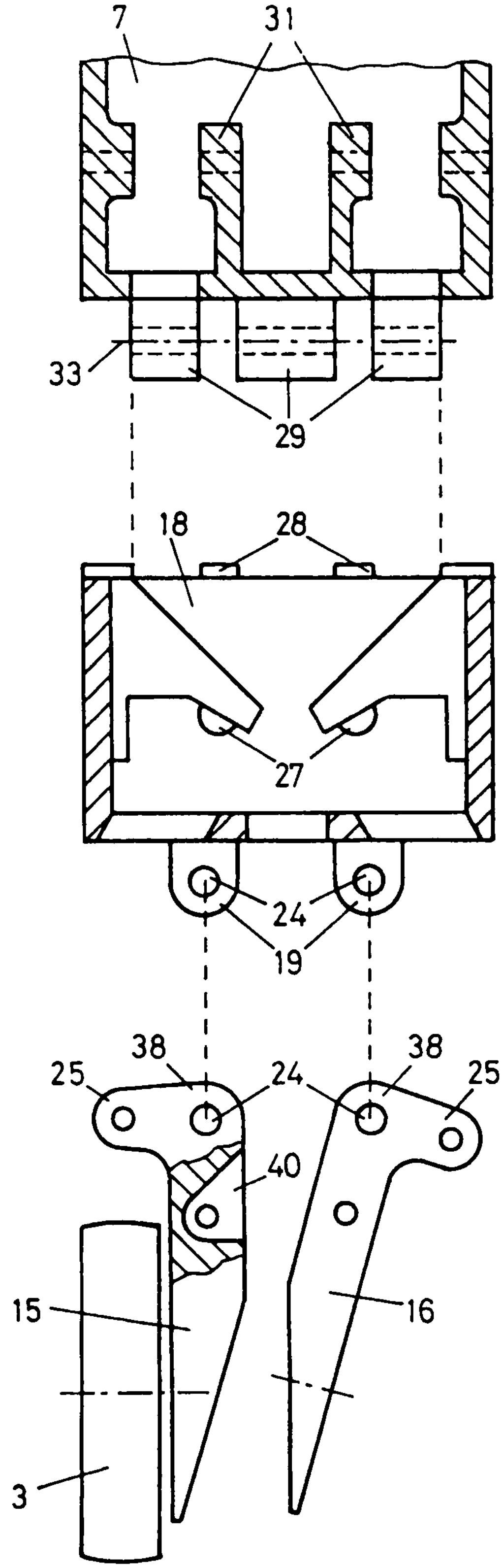
Fig.7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EUROPEAN SEARCH REPORT

Application Number

EP 91 10 1361

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
	EP-A-109 907 (SOLETANCHE)		E02D17/13
X	* page 1, line 14 - line 34 *	1,2,4,10	
A	* page 3, line 13 - page 4, line 26; figures 1-5 *	11,12	
X	PATENT ABSTRACTS OF JAPAN vol. 12, no. 466 (M-772)(3313) December 7, 1988 & JP-A-63 189 526 (TONE BORING) * the whole document *	1,3,5	
	US-A-3 683 522 (ROUSSEAU)		
X	* column 4, line 19 - line 35; figures 10,11 *	1	
	DE-A-3 805 868 (HOCHTIEF)		
X	* column 3, line 3 - line 27; figure 2 *	1	
	DE-A-3 602 387 (HOCHTIEF)		
A	* column 2, line 32 - column 3, line 19; figures 1-4 *	1-5, 10-12	
	FR-A-2 211 027 (SOLETANCHE)		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	* page 1, line 21 - line 38 *	13	
	* page 3, line 5 - line 12; figure 1 *		E02D
	DE-A-2 655 317 (SCHYMURA)		E02F
A	* page 4, line 1 - line 25 *	13	E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 SEPTEMBER 1991	BELLINGACCI F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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